REMARKS/ARGUMENTS

Restriction Requirement

Claims 1-44 are pending in this Application, and have been made subject to a Restriction Requirement, in which claims 22 and 44 were said to represent one invention, while the remainder of the claims represented the other invention. The Requirement was discussed in a previous Response, and the Examiner has now made this particular action final. Applicant continues to maintain that all of the claims represent one inventive embodiment, but assents to the division of claims, as noted previously. Applicant also acknowledges the obligation to associate the proper inventors with the claims remaining in the case.

Claim Rejections – 35 U.S.C. 103

Claims 1-21 and 23-43 have been rejected under 35 U.S.C. 103, as being unpatentable over U.S. Patent 4,836,849, issued to Svedberg et al ("Svedberg") and U.S. Patent 6,692,586, issued to Xu et al ("Xu"), in view of U.S. Patent 6,428,910, issued to Jackson et al ("Jackson"). Applicant is unsure as to which of the first two references is (are) actually being applied. Although "Xu et al" is repeatedly noted in paragraph 4 of the Office Action, the Examiner appears to be referring to sections of Svedberg at times. Applicant will presume that Xu is the "primary" reference, but clarification from the Examiner would be appreciated. Notwithstanding the discrepancy, it appears to be the Examiner's position that one or both of the first-mentioned references describes the process steps of the present invention.

A few brief words regarding the present invention would be appropriate. Niobium-based refractory metal-intermetallic composites (RMIC's), such as the niobium-silicide alloys, provide an unusual combination of properties, as noted in paragraph 3 of the specification. The materials can withstand very high temperatures – much higher than with traditional nickel-based superalloys. Moreover, the ductile metal phase (Nb-based) and the relatively brittle

intermetallic phase (often Si-based) provide a very useful combination of mechanical properties over a wide range of temperatures. These properties include low-temperature toughness and high-temperature strength and creep-resistance. Thus, RMIC's like the Nb-Si alloys (exemplified here) are extremely valuable for possible use in demanding applications like gas turbine engines.

While RMIC's have tremendous potential, their manufacture can be very difficult. As described in paragraph 4, the typical thermo-mechanical forming, casting, and solidification techniques cannot always be used with RMIC materials which have such high melting temperatures. For example, extrusion temperatures of about 1450°C-1650°C are required, with minimal dimensional change. Moreover, the complex chemistry and high reactivity of these alloys make microstructural control difficult to achieve, resulting in a greater incidence of defective castings.

In response to the serious challenges present in this technology, the present inventors conceived a unique fabrication technique. A refractory metal precursor phase is first blended with a silicide precursor phase to form a powder blend. The blend is then consolidated and mechanically deformed at a first temperature level. The resulting material is then reacted at a second, higher temperature, to form both the metal phase and the intermetallic phase. This process can provide a greater degree of compositional and microstructural control. One important advantage of such control is the ability to obtain complex component geometries, critical for components such as high pressure turbine blades. Moreover, the fabrication can take place at relatively low temperatures, with a reduced need for time-consuming, post-process machining.

Some of the key features of this invention are set forth in claim 1, which now includes additional limitations discussed below. Moreover, claims 3 and 5-9 set forth some of the specific alloys which are preferred for certain applications of the RMIC's. Claims 10 and 11 set forth consolidation and deformation techniques, respectively, while claims 12-17 recite specific time- and temperature conditions which are preferred in some embodiments. Claim 18 is directed to an RMIC composite which has a graded structure. Claims 19-20 are

directed to coatings which can be applied over the composite. Claim 21 recites a high-energy ball milling technique which is employed to coat a layer of the refractory metal onto the powder of the silicide precursor. Claims 23-43 are directed to other embodiments which relate to similar subject matter like that of the described claims.

Xu describes high-temperature braze materials, which contain one or more base elements, such as Ti, Ta, Nb, Hf, Si, and Ge (element symbols used here). The compositions also include a secondary element selected from Cr, Al, Nb, B, Si, Ge, and mixtures thereof. (See col. 4, lines 9-26). The constituents are combined to form a braze composition, i.e., a lower-melting composition used to join articles made from higher-melting structural materials, like the RMIC's. While the composition of Xu may contain some elements which happen to be similar to some elements of the present invention, the overall braze material has nothing to do with the present invention.

It is difficult to determine which part of the Xu reference is being used as an example of Applicant's process steps. While the constituents in Xu need to be combined in some way, there appears to be no specific teaching regarding the combination. Again, Applicant needs to understand what part of the reference is being referred to in paragraph 4 of the Office Action. Nonetheless, <u>Xu fails to disclose or suggest the mechanical deformation/reactions steps for the refractory metal/silicide precursor, as in the present claims</u>.

Moreover, the Xu patent also fails to suggest the higher-temperature reaction step recited in Applicant's claim 1, wherein the metal-intermetallic phases are formed. Certainly, the Xu compositions are heated at some point (e.g., Example 1, bottom of column 9, regarding vacuum arc melting). However, it appears that most of the heating steps in the reference <u>are in no way similar</u> to Applicant's powder blend-reaction step. They instead simply relate to heating steps as part of the <u>brazing process</u>, (col. 8, lines 55-65; and Examples 2-4). When two different temperature levels are incorporated into the process (col. 8, line 65 to col. 9, line 10), it has nothing to do with <u>preparation of an RMIC</u>. It is simply a heating scheme to form a <u>brazed diffusion bond</u>. The use of a "foil" (see

paragraph 4 of the Office Action) is also directed only to the brazing of adjacent layers, regardless of how the foil is "heat-treated" (see col. 7, lines 37-49).

For similar reasons, the other pending claims are nonobvious in view of the Xu reference. For example, Xu clearly mentions Nb-Si alloys which might be similar to some of the alloys recited in the rejected claims. However, the alloys are described only in the context of structural parts being <u>joined</u> or repaired by the braze compositions. The reference also never specifically suggests any of Applicant's mechanical deformation, consolidation, and higher-temperature reaction steps, or the temperature/time conditions related to those steps. Thus, Applicant strongly suggests that this reference should be removed, relative to the claims under examination.

Svedberg describes oxidation resistant niobium alloys. The materials are shaped and formed by mechanically alloying a powdered niobium alloy with powdered intermetallic compounds. The preparation steps involve intimately mixing the constituents, altering the particle size distribution, and then forming the resulting material into a desired shape. (See col. 1, lines 48-55). The mechanical alloying-step can be carried out by a variety of techniques, such as ball-milling. The composition can then be formed into a desired shape by a consolidation technique such as hot pressing, explosive bonding, and the like. The article can be coated with an oxidation-resistant coating (col. 3, lines 25-42). The materials appear to be directed to combinations of niobium with aluminum, iron, cobalt, or chromium (col. 2, lines 43-46).

While Svedberg contains some steps which are similar to those of the present invention, the reference fails to describe the consolidation-deformation/reaction steps for a refractory-<u>silicide</u> composition, as in the present invention. As mentioned previously and described in the specification, the presence of the <u>silicide phase</u> is critical for providing a specific combination of strength and oxidation resistance over a wide-ranging temperature environment. (While Svedberg happens to mention certain "silicides", as in column 3, lines 35-40, it is only in reference to <u>coatings</u> which are applied over the niobium alloy part).

In regard to Applicant's other pending claims, Svedberg certainly mentions some of the individual elements in the alloys, but fails to describe silicide-based RMIC's which include such elements. It is also not clear as to whether Svedberg suggests Applicant's specific temperature/time schedules. Moreover, Svedberg fails to suggest the preparation of the graded composite recited in pending claim 18. As described in paragraph 13, the claimed process can be used to incorporate property gradients into a shaped part, so that different sections of the part have different attributes. Svedberg contains no suggestion of such a concept.

Jackson describes specific types of RMIC composites, based on a combination of elements, including Nb, Si, Ta, Ti, and Hf, as well as other elements (col. 3, lines 33-38). The composites include a core and an overlying surface layer (col. 3, lines 56-63). A general description of the preparation of the alloys is provided in column 6, lines 8-19.

While Jackson certainly describes niobium silicide composites, the reference never suggests the processing steps of the present invention. The preparation description provided in column 6 is a general teaching which does not address the problems which prompted the discovery of the present invention.

It appears that Jackson is being applied for its teaching of a "graded composition". However, Jackson only describes a graded surface layer. (col. 3, lines 25-29; col. 4, lines 33-41; claim 29). The reference never describes the preparation of a graded composite by a sequence of specific deformation/reaction steps, as in the present invention.

Claims 1 and 23 have been amended to include limitations which further highlight some of the preferred features for embodiments of the present invention. The limitations are directed to specific materials which can be employed in the formation of the first and second powders. The subject matter has been taken from dependent claims which have appropriately been canceled, and there should be no issues of new matter.

Conclusion

Applicant submits that the pending claims – those which are original and those which are amended - are patentable over the cited references. It is thus requested that the case be placed in allowance. The undersigned would be interested in discussing any remaining issues with the Examiner, if an interview might resolve those issues.

Respectfully submitted,

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